CLAIMS

Claim 1. A transmitting apparatus for transmitting a multi-carrier modulated signal having a plurality of sub-carriers modulated in accordance with transmission data, comprising:

a mapping circuit for arranging signal points with respect to said plurality of sub-carriers in accordance with a predetermined modulation method based on said transmission data and forming a transmission signal,

a pilot addition circuit for inserting a transmission path estimation pilot signal in the transmission signal output from said mapping circuit, and

an orthogonal transform circuit for orthogonally transforming the transmission signal having said pilot signal added thereto.

Claim 2. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit determines a number of insertions of said pilot signal in each modulation time in accordance with an attribute of said transmission data.

Claim 3. A transmitting apparatus as set forth in claim 1, wherein pilot addition circuit determines a number of insertions of said pilot signal in each modulation in time in accordance with one of a size of said transmission data and a perceived importance of said transmission data.

Claim 4. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit determines a number of insertions of said pilot signal in each modulation time in accordance with a state of a transmission channel.

Claim 5. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit determines, a number of insertions of said pilot signal in each modulation time in accordance with a possibly of retransmission of said transmission data when a transmitting operation fails.

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Claim 6. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit inserts said pilot signal with a highest ratio at a start of the transmission where, when the modulated signal of each sub-carrier in one modulation time is one symbol, the ratio of the pilot signal is defined by number of pilot symbols number of information symbols.

Claim 7. A transmitting apparatus as set forth in claim 6, wherein said pilot addition circuit inserts said pilot signal with a every modulation time.

Claim 8. A transmitting apparatus as set forth in claim 6, wherein said pilot addition circuit inserts said pilot signal with a ratio (1/m) (m is a natural number) at a modulation time t0 immediately after the start of the transmission and inserts said pilot signal with a ratio (1/(m+n)) at a modulation time tn (n is a natural).

Claim 9. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit inserts said pilot signal with a ratio (1/2m) (m is a natural number) at the modulation time t0 immediately after a start of the transmission and inserts said pilot signal with a ratio (1/2(m+n)) at the modulation time tn (n is a natural number).

Claim 10. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit holds a ratio of said pilot signal constant when a predetermined time elapse after a start of the transmission.

Claim 11. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit stops the addition of the pilot signal when a predetermined time elapses after a start of the transmission.

Claim 12. A transmitting apparatus as set forth in claim 1, wherein said pilot addition circuit changes a position of insertion of said pilot signal when every modulation time while holding a ratio of the pilot signal constant.

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Claim 13. A transmitting apparatus as set forth in claim 1, wherein said orthogonal transform circuit performs an inverse Fourier transform on the transmission signal having pilot signal added thereto.

Claim 14. A receiving apparatus for receiving a multi-carrier modulated signal having a pilot signal added thereto by a transmitting apparatus, the receiving apparatus comprising:

an orthogonal transform circuit for orthogonally transforming a received signal,

a transmission path estimation circuit for extracting said pilot signal based on an output signal of said orthogonal transform circuit and estimating a transmission path in accordance with the extracted pilot signal, and

a data output circuit for correcting said received signal in accordance with a result of the estimated transmission path of said transmission path estimation circuit and outputting the received signal.

Claim 15. A receiving apparatus as set forth in claim 14, wherein said transmission path estimation circuit has a transmission path equalization circuit for extracting said pilot signal from the output signal of said orthogonal transform circuit and estimating characteristics of the transmission path in accordance with the extracted pilot signal.

Claim 16. A receiving apparatus as set forth in claim 15, wherein the transmission path equalization circuit includes:

a pilot extraction circuit for extracting said pilot signal from the output signal of said orthogonal transform circuit,

a first addition circuit for dividing an extracted pilot signal into groups provided in accordance with frequency band and adding the pilot signals of the groups and at least one pilot signal selected from an adjoining group,

a multiplication circuit for multiplying a result of the addition of pilot signals at an adjoining previous modulation time on the time axis by a predetermined coefficient, and

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a second addition circuit for adding the result of the addition of the addition circuit at a present point of time and an output signal of said multiplication circuit.

Claim 17. A receiving apparatus as set forth in claim 16, wherein said transmission path identification circuit outputs a transmission path vector showing transmission characteristics of the transmission path.

Claim 18. A receiving apparatus as set forth in claim 17, comprising a second multiplication circuit for multiplying the output signal of said orthogonal transform circuit and a conjugate of said transmission path vector, wherein said data output circuit finds said received data in accordance with an output signal of said second multiplying circuit.

Claim 19. A receiving apparatus as set forth in claim 18, wherein said data output circuit finds the received data in accordance with the output signal of said second multiplication circuit and the modulation method.

Claim 20. A receiving apparatus as set forth in claim 14, wherein wherein said orthogonal transform circuit performs a Fourier transform on said received signal.

Claim 21. A communication system for transmitting and receiving a mult-carrier modulated signal produced in accordance with transmission data, comprising:

a mapping circuit for arranging signal points with respect to said plurality iof sub-carriers in accordance with a predetermined modulation method based on said transmission data,

a pilot addition circuit for inserting a transmission path estimation pilot signal in an output signal of said mapping circuit,

a first orthogonal transform circuit for orthogonally transforming an output signal of said pilot addition circuit,

a transmission circuit for transmitting an output signal from said transmission path,

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A reception circuit for receiving a transmission signal from said transmission path,

a second orthogonal transform circuit for orthogonally transforming a received signal received by said reception circuit,

a transmission path estimation circuit for extracting said pilot signal based on the output signal of said second orthogonal transform circuit and estimating the transmission path in accordance with the extracted pilot signal, and

a data output circuit for correcting said received signal in accordance with a result of estimation of said transmission path estimation circuit and outputting data of the received signal.

Claim 22. A communication system as set forth in claim 21, wherein said pilot addition circuit controls insertion of said pilot signal in accordance with an attribute of said transmission data.

Claim 23. A communication system as set forth in claim 22, wherein said pilot addition circuit determines a number of insertions of said pilot signal in each modulation time in accordance with one of a size of said transmission data and a perceived importance of said transmission data.

Claim 24. A communication system as set forth in claim 21, wherein said pilot addition circuit determines a number of insertions of said pilot signal in each modulation time in accordance with a state of a transmission channel.

Claim 25. A communication system as set forth in claim 21, wherein said pilot addition circuit determines a number of insertions of said pilot signal in each modulation time in accordance with a possibility of retransmission of said transmission data when a transmission operation fails.

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Claim 26. A communication system as set forth in claim 21, wherein said pilot addition circuit inserts said pilot signal with a highest ratio at a start of transmission where, when the modulated signal of each sub-carrier in one modulation time is one symbol, the ratio of the pilot signal is defined by (number of pilot symbols/number of information symbols).

Claim 27. A communication system as set forth in claim 26, wherein said pilot addition circuit reduces the ratio of said pilot signal every modulation time.

Claim 28. A communication system as set forth in claim 26, wherein said pilot addition circuit inserts said pilot signal with a ratio (1/m) (m is a natural number) at a modulation time t0 immediately after a start of the transmission and inserts said pilot signal with a ratio (1/(m+n)) at a subsequent modulation time tn (n is a natural number).

Claim 29. A communication system as set forth in claim 26, wherein said pilot addition circuit inserts said pilot signal with a ratio (1/2M) (m is a natural number) at the modulation time t0 immediately after the start of the transmission and inserts said pilot signal with a ratio (1/2(m+n)) at a subsequent time tn (n is a natural number).

Claim 30. A communication system as set forth in claim 26, wherein said pilot addition circuit holds the ratio of said pilot signal at a constant when a predetermined time elapse after the start of the transmission.

Claim 31. A communication system as set forth in claim 26, wherein said pilot addition circuit stops the addition of the pilot signal when a predetermined time elapses after the start of the transmission and makes the ratio zero.

Claim 32. A communication system as set forth in claim 30, wherein said pilot addition circuit changes a position of insertion of said pilot signal with every modulation time, while holding the ratio of the pilot signal at a constant.

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Claim 33. A communication system as set forth in claim 21, wherein said first orthogonal transform circuit performs an inverse Fourier transform on the transmission signal having the pilot signal added thereto.

Claim 34. A communication system as set forth in claim 21, wherein said second orthogonal transform circuit performs a Fourier transform on the transmission signal received by the reception circuit.

Claim 35. A communication system as set forth in claim 21, wherein said transmission path estimation circuit has a transmission path equalization circuit for extracting said pilot signal from the output signal of said second orthogonal transform circuit and estimating characteristics of the transmission path in accordance with the extracted pilot signal.

Claim 36. A communication system as set forth in claim 35, wherein the transmission path equalization circuit includes:

a pilot extraction circuit for extracting said pilot signal from the output signal of said second orthogonal transform circuit,

a first addition circuit for dividing extracted pilot signals into groups provided in accordance with frequency bands and adding the pilot signals of the groups and at least one pilot signal selected from an adjoining group,

a multiplication circuit for multiplying a result of the addition of the pilot signals at the adjoining previous modulation time on a time axis by a predetermined coefficient, and

a second addition circuit for adding the result of the addition of the pilot signals at the adjoining previous modulation time on a time axis by a predetermined coefficient, and

a second addition circuit for adding the result of the addition of the addition circuit at a present point of time and an output signal of said multiplication circuit.

Claim 37. A communication system as set forth in claim 36, wherein said transmission path estimation circuit outputs a transmission path vector showing transmission characteristics of the transmission path.

Claim 38. A communication system as set forth in claim 37, comprising a second multiplication circuit for multiplying an output signal of said second orthogonal transform circuit and a conjugate of said transmission path vector, wherein said data output circuit finds received data in said received signal in accordance with an output signal of said second multiplication circuit.

Claim 39. A communication system as set forth in claim 38, wherein said data output circuit finds said received data in accordance with the output signal of said second multiplication circuit and the predetermined modulation method.
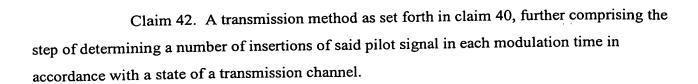
Claim 40. A transmission method for transmitting a multi-carrier modulated signal having a plurality of sub-carriers modulated in accordance with transmission data, comprising the steps of:

arranging signal points with respect to said plurality of sub-carriers in accordance with a predetermined modulation method based on said transmission data,

inserting a transmission path estimation pilot signal in an output signal of said step of arranging in accordance with an attribute of said transmission data, and

orthogonally transforming a transmission signal having said pilot signal inserted therein.

Claim 41. A transmission method set forth in claim 40, further comprising the step of determining a number of insertions of said pilot signal in each modulation time in accordance with one of a size and importance of said transmission data.

Claim 42. A transmission method as set forth in claim 40, further comprising the step of determining a number of insertions of said pilot signal in each modulation time in accordance with a state of a transmission channel.

Claim 43. A transmission method as set forth in claim 40, further comprising the step of determining a number of insertions of said pilot signal in each modulation time in accordance with a possibility of retransmission of said transmission data when a transmission operation fails.

Claim 44. A transmission method as set forth in claim 40, further comprising the step of inserting said pilot signal with a highest ratio at a start of the transmission where, when the modulated signal of each sub-carrier in one modulation time is one symbol, a ratio of the pilot signal is defined by (number of pilot symbols/number of information symbols).

Claim 45. A transmission method as set forth in claim 44, further the step of comprising reducing the ratio of said pilot signal every modulation time.

Claim 46. A transmission method as set forth in claim 44, further comprising the step of inserting said pilot signal with a ratio (1/m) (m is a natural number) at a modulation time t0 immediately after a start of the transmission and inserting said pilot signal with a ratio (1/(m+n)) at a subsequent modulation time tn (n is a natural number).

Claim 47. A transmission method as set forth in claim 44, further comprising the step of inserting said pilot signal with a ratio (1/2m) (m is a natural at a modulation time t0 immediately after a start of the transmission and inserting said pilot signal with a ratio (1/2(m+n)) at a subsequent modulation time tn (n is a natural number).

Claim 48. A transmission method as set forth in claim 45, further comprising the step of holding the ratio of said pilot signal constant when a predetermined time elapses after a

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start of the transmission .

Claim 49. A transmission method as set forth in claim 44, further comprising the step of stopping the insertion of the pilot signal when a predetermined time elapses after the start of the transmission (makes the ratio zero).

Claim 50. A transmission method as set forth in claim 48, further comprising the step of changing a position of insertion of said pilot signal with every modulation time, while holding the ratio of the pilot signal constant.

Claim 51. A reception method for receiving a multi-carrier modulated signal having pilot signal added thereto by a transmitting apparatus, comprising the steps of:

    orthogonally transforming a received signal,

    extracting said pilot signal based on said orthogonally transformed received signal,

    estimating a transmission path in accordance with the extracted pilot signal,

    correcting said received signal in accordance with a result of said estimation of the transmission path, and

    outputting the data of the received signal.

Claim 52. A reception method set forth in claim 51, further comprising the step of estimating characteristics of the transmission path in accordance with said extracted pilot signal and correcting a phase and an amplitude of the received signal in accordance with results of said estimation of the characteristics.

Claim 53. A communication method for transmitting and receiving a multi-carrier modulated signal having a plurality of sub-carriers in accordance with transmission data, comprising the steps of:

    arranging signal points with respect to said plurality of sub-carriers in accordance with a predetermined modulation method based on said transmission data,

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inserting a transmission path estimation pilot signal in an output signal produced in said step of arranging in accordance with an attribute of said transmission data,

orthogonally transforming a transmission signal having said pilot signal added thereto,

transmitting said orthogonally transformed signal over a transmission path,

receiving the transmission signal from said transmission path,

orthogonally transforming a received signal,

extracting said pilot signal based on said orthogonally transformed received signal,

estimating the transmission path in accordance with the extracted pilot signal,

correcting said received signal, and

outputting the data of the received signal.

Claim 54. A communication method set forth in claim 53, further comprising the step of inserting said pilot signal with a highest ratio at a start of the transmission where, when the modulated signal of each sub-carrier in one modulation time is one symbol, the ratio of the pilot signal is defined by (number of pilot symbols/number of information symbols).

Claim 55. A communication method set forth in claim 54, further comprising the step of reducing the ratio of said pilot signal every modulation time.

Claim 56. A communication method as set forth in claim 54, further comprising the step of inserting said pilot signal with a ratio (1/m) (m is a natural number) at a modulation time t0 immediately after the start of the transmission and inserts said pilot signal with a ratio (1/2(m+n)) at a subsequent modulation time tn (n is a natural number).

Claim 57. A communication method as set forth in claim 54, further comprising the step of inserting said pilot signal with a ratio (1/2m) (m is a natural number) at the modulation time t0 immediately after the start of the transmission and inserts said pilot signal with a ratio (1/2(m+) at a subsequent modulation time tn (n is a natural number).